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Adult Age and the Rate of an Internal Clock

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Two experiments were conducted to determine whether young and old adults differ in the rate of a hypothetical internal clock. Clock rate was measured as the slope of the function relating actual duration to perceived duration. No age differences were apparent when subjects were asked to judge the duration of a flash of light in Exp. I, or to judge the duration of a dark interval between two light flashes in Exp. II. It was concluded that there is no evidence to support the hypothesis that perceptual and motor speed differences associated with increased age can be attributable to a slower rate of internal time.

ONE possible cause for the slower perceptual-motor performance of older adults (Welford, 1977) is that an internal timing mechanism responsible for coordinating neural activities operates at a slower rate with increased age (Surwillo, 1968). For example, if the hypothetical internal clock functioned half as rapidly in 60-year-olds as in 20-year-olds, one would expect an older adult to require approximately twice as long as a young adult to perform the same sequence of mental processes. This point may be illustrated by modifying an example used by Surwillo (1968). Assume that a young subject with a fast (12 cps) internal clock and an old subject with a slow (6 cps) internal clock both perform a reaction time task that requires exactly two units of internal time. These two units would correspond to 167 msec of external time for the young subject, but 333 msec for the old subject. As long as mental processes are organized and calibrated in terms of internal time, there would always be a two-to-one difference in physical time even if the two subjects are performing exactly the same operations.

In order for the internal clock interpretation to receive serious consideration, it must be demonstrated that some measure of clock rate differs between young and old adults. Several studies employing time estimation tasks have failed to find age differences in estimation accuracy (Arenberg, 1968; Smythe & Goldstone, 1957; Surwillo, 1964), but two characteristics of these studies may be responsible for the negative results. First, the Surwillo (1964) experiment utilized relatively long durations ranging from one to 30 sec and thus the subjects could have used counting strategies instead of having to rely directly on the internal clock for timing. A better procedure might have been to present durations in the msec range to minimize the use of explicit counting strategies.

The second undesirable characteristic of the earlier studies is that the measures of internal clock rate were very indirect. The procedure typically involved comparing the accuracy of estimating one to three temporal intervals in individuals of different ages. The direction and magnitude of the estimation errors could then be used to make inferences about the tempo of the internal clock. The problem with this procedure is that estimation errors could be produced by differences between subjective time and objective time if the function relating subjective time to objective time either had an intercept different from zero, indicating a calibration problem, or if the function had a slope different from one, signifying a rate discrepancy. Thus, any differences between age groups could not be unambiguously interpreted as indicating a difference in internal clock rate unless one could be certain that the calibration or response mapping was the same in all age groups. Moreover, compensatory age differences in both slope and calibration could lead to no difference in time estimation even if the rate of the internal clock did differ.

A more direct method of comparing internal clock rates involves the presentation of many

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different durations to be estimated, and empirically determining the function relating estimated duration to actual duration. Since the slope of this function indicates the relationship between subjective and objective time, it can be used as a straightforward measure of the rate of the internal clock. Slow rates would be indicated by small slopes while fast rates would be represented by large slopes.

The purpose of the current experiments was to incorporate the procedural improvements discussed above in an investigation of possible age differences in internal clock rate. Two different methods of presenting time intervals were utilized in two separate experiments to determine whether the mode of presentation influenced the pattern of results. Specifically, it might have been expected that one group of subjects would have found a single light pulse easier to estimate than a dark interval between two light pulses because of asymmetry of signal persistence. That is, the light signal might persist in the dark interval following the light, but it is unlikely that a dark signal would persist in a following light period. The results did not support any differential effects of this type, however, and thus the two experiments are treated as independent replications of the same phenomenon and will be discussed together.

METHOD

Subjects

Both experiments had individuals between the ages of 18 and 35 in the young group and individuals between the ages of 55 and 80 in the old group. There were 15 young and 18 old subjects in Exp. I, and 23 young and 22 old subjects in Exp. II. Two additional subjects,

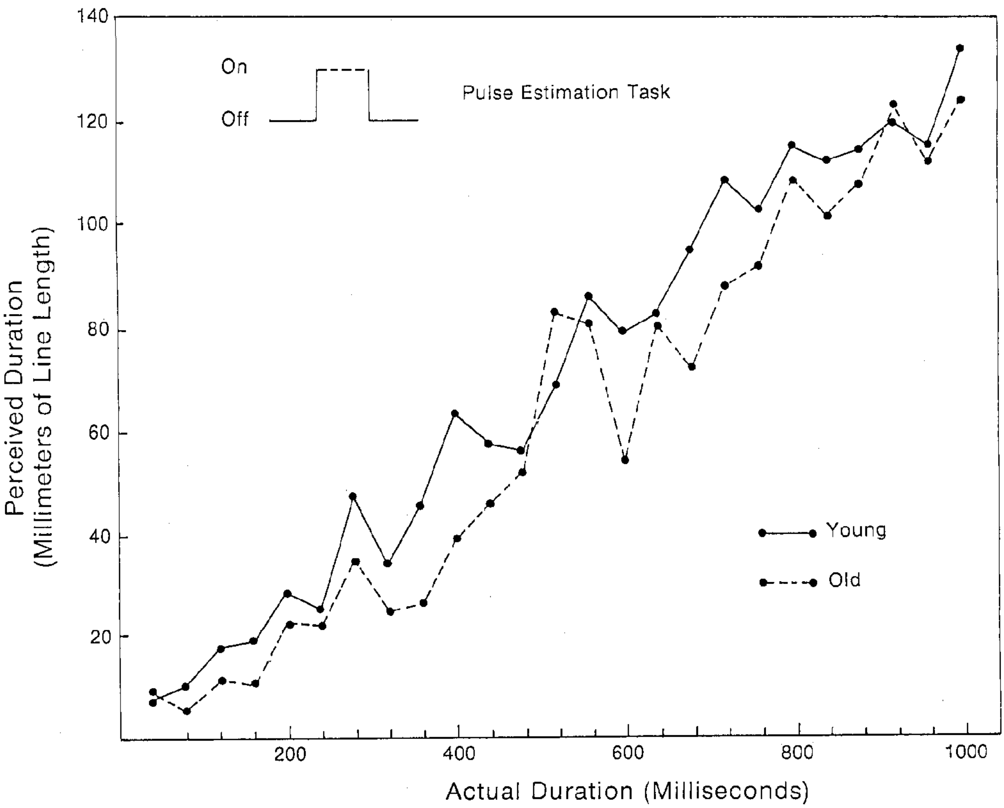

Fig. 1. Perceived duration in millimeters of line length vs actual duration in msec for the pulse estimation task of Exp. I.

one young and one old, had to be discarded from Exp. II because of failure to follow instructions. All subjects were community residents reporting themselves to be in good health.

The subjects in both experiments were tested after participating in 40 to 90 min of unrelated tachistoscopic perception or memory tasks.

Apparatus and Procedure

A Gerbrands G1130 three-field tachistoscope was used for timing control and stimulus presentation.

The subjects were given a response sheet containing 25 horizontal lines 153 mm in length. They were instructed that a variety of durations would be presented and that they should attempt to estimate the magnitude of each duration by placing short vertical lines at the position on the horizontal line corresponding to the duration. If the duration was judged to be short, the vertical line would be placed close to the left edge of the line that represented 0 sec. Or, if the duration was judged to be long, the vertical line would be placed close to the right edge of the line that represented 1.0 sec. All durations were to be estimated in a similar fashion with the subject adjusting the magnitude of horizontal line length to correspond to the magnitude of duration.

The stimuli consisted of 25 durations from 40 to 1000 msec in 40 msec steps. Two random arrangements of the durations were used, with approximately one-half of the subjects in each age group receiving each arrangement. No differences in performance were observed across the two presentation sequences.

The only change between Exp. I and II was the manner of presenting the temporal dura-

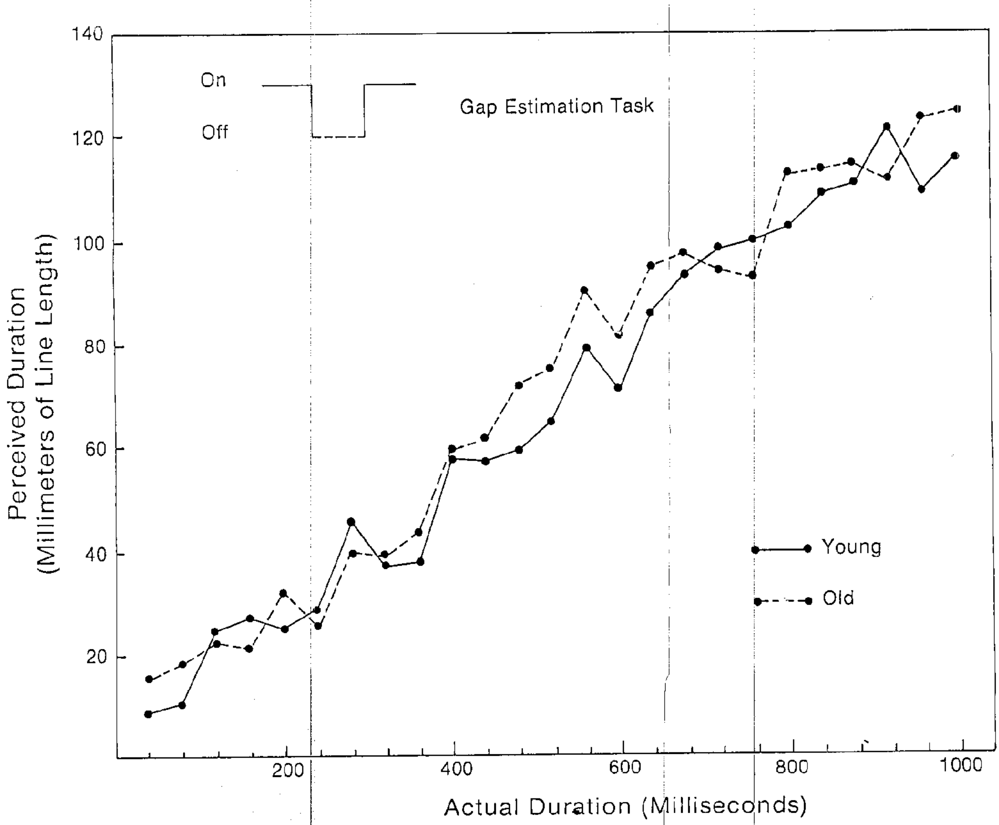

Fig. 2. Perceived duration in millimeters of line length vs actual duration in msec for the gap estimation task of Exp. II.

tions. In Exp. I the durations were represented as single pulses of light, whereas in Exp. II the durations were represented as the dark interval between two pulses of light. The light fields in both experiments were homogeneous white surfaces exposed at a luminance of 2.0 cd/cm^2.

RESULTS

The mean line length for each stimulus duration is displayed in Fig. 1 and 2 for Exp. I and II, respectively. The suggestion from these data is that the rate of increase in perceived duration with increases in objective duration is very similar in the two age groups.

In order to conduct statistical tests on these data, the slope of the least-squares linear regression function relating line length to actual duration was computed for each subject. Correlation coefficients were also determined to evaluate the accuracy with which the regression parameters served to describe the functions. The mean slopes and correlations (computed by averaging z-scores) are displayed in Table 1. As is indicated in the table, no age differences were significant with the slope or correlation measure in either experiment.

DISCUSSION

No differences were observed in these experiments between young and old adults in the rate of change in perceived duration relative to actual duration. Three factors suggest that this is an accurate reflection of the true state of affairs and not merely a failure to detect a real difference. First, the correlation coefficients were quite high, indicating that the slope measures were valid descriptors of the functions. Second, the absence of age differences was replicated in the two independent experiments reported here. And third, this finding is consistent with the reports of earlier investigators that young and old adults are equally accurate at estimating temporal durations.

Two interpretations are possible with respect to the hypothesis that there are age differences in the rate of the internal clock. The obvious interpretation is that the hypothesis is incorrect since the present results indicate that there are no age differences in the slope variable, which seems to be a direct measure of internal clock rate. According to this interpretation, then, some mechanism other than an internal clock needs to be invoked to account for age-related slowing phenomena.

An alternative explanation of these results is that the internal clock hypothesis is still valid, but that the slope measure did not accurately assess internal clock rate. The problem could be that the slope measure was inappropriate, or that intervening processes serve to reestablish the correspondence between judgment and external time despite a slowing of internal time. For the reasons discussed in the introduction it seems unlikely that the slope variable is inappropriate for measuring internal clock rate. Postulation of an additional transformation process between the internal clock and judgment complicates matters, but it could explain why an age difference in internal clock rate is not reflected in an age difference in external time estimation. For example, in a young adult two units of subjective time might correspond to two units of objective time, while in an older adult the correspondence might be one unit of subjective time to equal two units of objective time. As long as the correspondence rules are available, the external time estimates can be equally accurate in both age groups despite a large difference in internal clock rate. This type of explanation seems to deny the possibility of ever obtaining direct evidence of internal clock rate, however, and therefore it is of limited usefulness in the current form. For this reason,

Table 1. Mean Slope and Correlation Parameters from Regression Equations Relating Perceived Duration to Actual Duration.

		Experiment I	Experiment II
Slope			
Young	Mean	.133	.121
	sd	.032	.032
Old	Mean	.131	.123
	sd	.034	.035
		$t(31) = .17$	$t(42) = -.20$
Correlation			
Young	Mean	.897	.868
	sd	.235	.325
Old	Mean	.835	.866
	sd	.285	.390
		$t(31) = .68$	$t(42) = .02$

the preferred conclusion from the present experiments is that there are no age differences in internal clock rate when rate is measured as the slope of the function relating actual duration to perceived duration.

SUMMARY

It has been proposed (Surwillo, 1968) that a slower rate of internal time might account for the slower perceptual and motor performance associated with increased age. A direct test of this notion was attempted in two experiments by examining possible age differences in the slope of the function relating actual (i.e., external) duration to perceived (i.e., internal) duration. No age differences were evident in either experiment and it was concluded that the hypothesis that older adults have a slower rate of internal time than younger adults must be rejected.

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